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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 922

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER December 21, 1920

CLOVER-LEAF WEEVIL.

By

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Cereal and Forage Crop Insect Investigations.

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INTRODUCTORY.

The clover-leaf weevil, *Hypera punctata* Fab. (fig. 1), ranks as one of the important clover pests. Although it is usually unnoticed, it annually exacts its toll of the crop. It seldom devastates entire fields, however, because the larvæ are ordinarily checked by an ever-present fungous disease which spreads rapidly and reduces their numbers to a negligible quantity in a remarkably short time.

DISTRIBUTION.

This insect was introduced accidentally into this country from Europe, where it is well known. It also occurs in northern Asia and probably in central Asia and China. So far as known it is the only species of Hypera that has reached this country, the genus being indigenous to the eastern hemisphere.

The first record of *Hypera punctata* occurring as a pest in the United States was in 1881 when a severe outbreak occurred at Barrington, N. Y. A single specimen taken about 1850–1855 in Canada by the Geological Survey and identified by Dr. LeConte in 1876 shows that this species had been in America for some time before becoming noticeable or seriously injurious.

In 1882 Lintner took a specimen in Vermont. In 1884 punctatus reached Canada in numbers, flying across the lake from Buffalo to Ridgeway, 1889 it occurred in several places in Ohio * * * and Schwarz identified a beetle taken from the stomach of a crow killed in Michigan in 1892 as this species. Southward by 1890 it had spread over New Jersey and reached Philadelphia, where it was very common. The year 1894 gave records from Maryland, West Virginia (Hopkins), and Indiana * * * Folsom records its first appearance at Urbana as 1903 * * * R. L. Webster reported it from Iowa in 1910. On the west coast Hanhem reported it from Vancouver in 1902 (Fletcher) and in 1906 E. S. Wilmot states that it was up the Fraser River as far as Harrisons, about 20 miles from the south line of British Columbia. (Titus *7, p. 405–406*).[1]

It is now found in the additional States of Delaware, Idaho, Kansas, Kentucky, Maine, Massachusetts, Mississippi, Missouri, Nebraska, New Hampshire, North Carolina, Oregon, Rhode Island, Tennessee, Texas, Utah, Virginia, Washington, and Wisconsin.

DESCRIPTION.

The descriptions are taken almost entirely from Titus (*7, p. 402–404*), with additions by the authors inclosed in brackets.

Adult [fig. 2]: Length 5 to 10 mm. Width 3 to 5.7 mm.

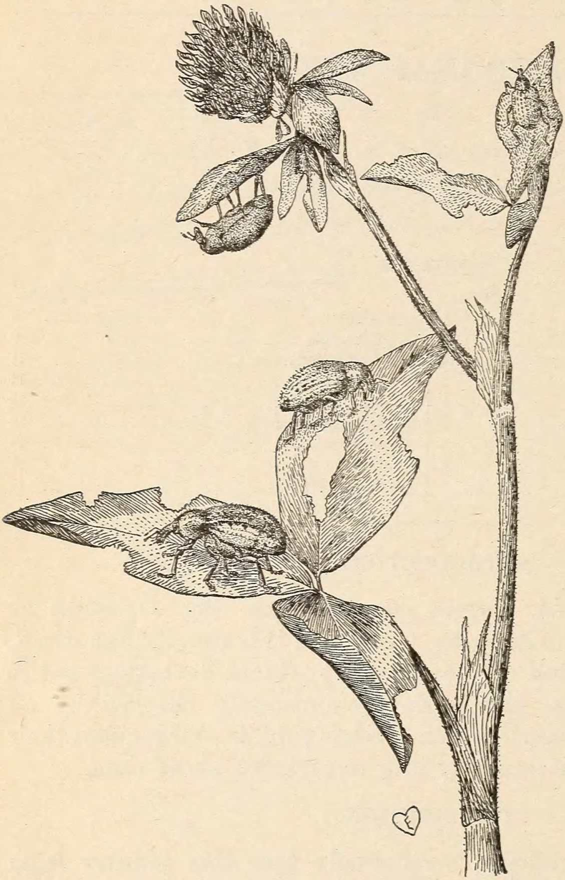

FIG. 1.—Adults of the clover-leaf weevil feeding.

Stout, black or brownish black. Clothed with blackish brown pale brown, yellow-brown or gray scales which are short broad and emarginate at the tips, and with short erect bristles, edge of elytra yellow brown or at least paler than remainder of scales. *Head* clothed with short metallic yellowish scales; *front* not as wide as breadth of eye, densely clothed with dark yellow hairs or scales which extend over two-thirds of the beak; *eyes* elongate oval, narrowed beneath, rather prominent; *beak* scarcely two-thirds the length of the prothorax, and one-half thicker at tip than width of front, beneath on the sides and near the tip polished and densely punctate; an elongate impression on dorsal surface above the antennal groove; antennal groove black, deep, punctured; *antennæ* reddish-black, scape reaching to middle of eyes, not as long as funicle, not greatly enlarged at tip; first joint of funicle distinctly longer than second, enlarged at the apex so that it is about one-half as thick as long, second joint equal to three and four united, joints three to seven regularly shorter and broader, seven as wide as long, club elongate-oval, pointed at the tip, antennæ with many fine hairs, those on club very fine and dense. Mandibles polished, dull red, not emarginate at tip, maxillæ and all the palpi pale brownish-red.

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[1] Reference is made by number (italic) to "Literature Cited," p. 18.

Prothorax broader than long, broader in female than in male, in the female broadly widened in front of the middle, in the male converging more behind than in female; sides broadly impressed, only slightly swollen; dorsum densely rather coarsely punctured, densely clothed with scales and with many slender pointed hairs; usually with a narrow pale median dorsal line bordered with wide dark, almost black in some, bands of scales which reach to the sides; sides and beneath with dark yellow scales, generally with a dark spot on sides behind and an indistinct dark line running from this spot toward the front.

Scutellum extremely small, narrowly triangular, clothed with pale scales.

Elytra very broad, at tip broadly rounded, sides especially in the male nearly parallel, humeri prominent and clothed with darker scales. Suture and alternate interspaces more strongly elevated than others, deeply striately punctured, striæ without setæ; each interspace with a single row of black setæ pointing backward and partially decumbent, more erect behind; tip of elytra and often the sides with some short white hairs. The coloration of the scales varies from solid gray to black, through various shades of brown yellows. Some specimens are tessellated with brownish-yellow and black, the tessellation usually on the more elevated interspaces.

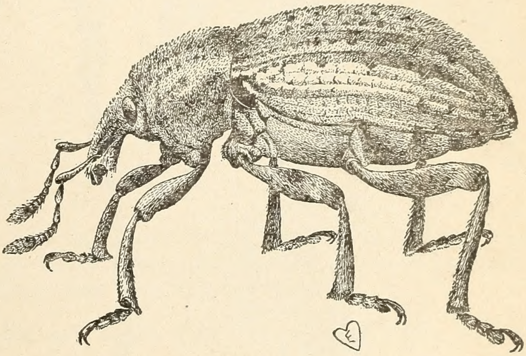

FIG. 2.—Adult clover-leaf weevil, lateral view. Much enlarged.

In the male the outer interspaces have paler scales even in the darkest specimens, in the female this pale coloration is sometimes, but rarely, entirely absent.

Venter with lighter colored scales and many light hairs; front coxæ slightly separated, mesosternal process between middle coxæ broad perpendicular, triangular at tip; intercoxal process of first abdominal segment very broad, coxæ separated by more than their width. First segment in male impressed, emarginate posteriorly. Stem of male genitalia nearly or quite as broad as long.

Legs short, stout, especially the femora; black, tarsi often ferruginous, claws long curved, red and darker at tips; front tibiæ and hind femora distinctly curved, front tibiæ more so in male; legs usually clothed with lighter scales and hairs than the body, femora scaled, tibiæ and tarsi sparsely haired; middle tibiæ with a distinct apical hook.

Egg [fig. 3]: Elongate oval, 1.1 mm. to 1.2 mm. long, 0.5 to 0.6 mm. broad, very regularly hexagonally sculptured * * *. [Watery yellow when laid, with a smooth shining shell, the yellow color deepening with age to pale olive green and finally turning to a dull black.]

Larvæ [2] (Descriptions from Riley, Folsom, and observations by the author). *First stage:* 1.5 to 2 mm. long, narrow, thickest at middle, tapering toward both ends;

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[2] The head widths for the different larval instars are quite constant and the averages will be found in Table I.

head brown, blackish-brown or black, with many fine transverse lines on the face; eyes very small, circular, projecting; mandibles terminating in two large sharp teeth, more or less separated, the lower one again divided into two or three parts; palpi pale yellow, mandibles brown or dark brown; dorsum of first thoracic segment with a rectangular dark band interrupted by a paler dorsal line which is the continuation of the stem of an inverted Y on the face, this dorsal band becomes wider on the abdominal segments and extends to the tip of anal segment. Hairs on the tubercles clavate as in several other species. [The color varies from the usual pale green to a bluish green or yellow when hatched. Yellow larvæ may retain this color throughout development.]

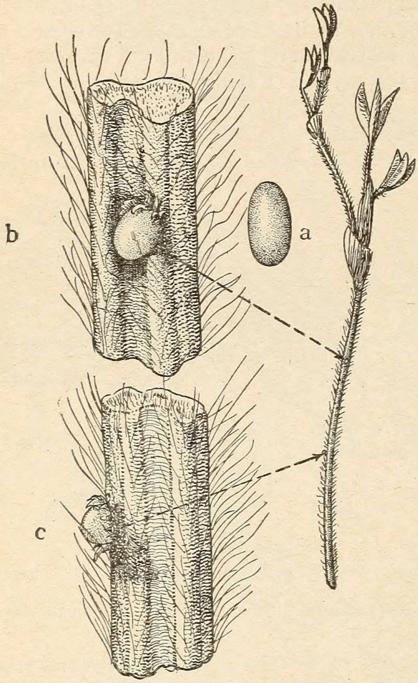

FIG. 3.—Egg of the clover-leaf weevil: *a*, Lateral view; *b*, egg inserted into stem of clover plant; *c*, lateral view of *b*. Much enlarged.

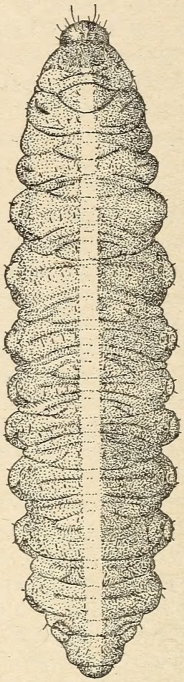

FIG. 4.—Full - grown larva of the clover-leaf weevil, dorsal view. Much enlarged.

Second stage: Color greener, head dark brown, front and sides of rectangular plate on first thoracic segment dark, the remainder greenish; dorsal median line with a fine dark border, darker than the remainder of the larva. Side line below spiracles indistinct. Length 4–4.5 mm., width 2 mm.

Third stage: Black lines on each side of dorsal line very distinct [head brown or yellowish brown], eyes densely black, antennæ darker. Color of larvæ (Folsom) may be blue green [yellow, or with a pinkish tinge]. Usual color pale green. Length 5 to 7 mm., width 2.5 to 3 mm. in the middle.

Fourth stage [fig. 4]: Dorsal line very white or pinkish, bordered by rose color, usually rather pale but sometimes rosy-black, the outer borders of this coloration are black and form distinct lines, interrupted on the margin of each segment [head brown or yellowish brown]; larva much darker green [or still may retain its yellow, blue green, or pink color]; lines below the spiracles dark both showing a tendency to be brown or blackish [posterior segments yellowish]; the surface of the body much rougher in this stage than in others, the triangular points of the cuticle standing out prominently; tubercles [fig. 5] on thoracic segments below very strong and the hairs more prominent than in earlier stages. Length 8 to 14 mm.

Cocoon [fig. 6]: * * * Oval, 9–10 mm. long and 6.5 to 7 mm. wide. [A fine network of coarse threads which are light straw color when spun and brown after aging.]

Pupa: When first formed with yellow-green head [lighter colored antennæ, legs and wing-pads] * * *. Abdomen dark green with a distinct pale dorsal line that extends onto prothorax * * *. Frontal row of hairs rather distant from margin; central pairs close together, three following pairs form a curved line ending near the posterior outer edge; a few hairs on remainder of thorax; transverse rows of blunt setæ on each dorsal abdominal segment; hairs on beak rather short and thin; those on anal segment moderately long, stout and dark. [The pigmentation of the eyes, mandibles, and leg joints occurs at later dates in order named.] Length 5.5–7 mm. Width 3.5–4.5 mm.

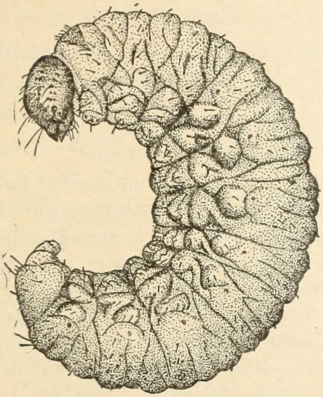

FIG. 5.—Full-grown larva of the clover-leaf weevil, lateral view. Much enlarged.

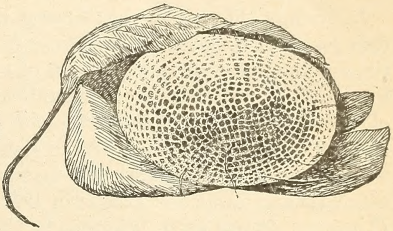

FIG. 6.—Cocoon of the clover-leaf weevil surrounded by leaves of clover plant. Enlarged.

The measurements of the larva are given in tabular form, as follows:

TABLE I.—*Larval measurements* (*mm.*) *of Hypera punctata.*

Number of specimens averaged.	First instar.				Second instar.			
	Width of head.	Length of body.			Width of head.	Length of body.		
		Minimum.	Maximum.	Average.		Minimum.	Maximum.	Average.
24	0.2	1.9	3.4	2.7				
20					0.55	1.8	5.9	3.8

Number of specimens averaged.	Third instar.				Fourth instar.			
	Width of head.	Length of body.			Width of head.	Length of body.		
		Minimum.	Maximum.	Average.		Minimum.	Maximum.	Average.
18	0.8	3.8	9.5	6.3				
19					1.2	5.1	13.1	9.3

FOOD PLANTS AND INJURY.

The food plants in Europe are listed as Trifolium (clover) and *Medicago sativa* (lucerne, alfalfa). In this country all kinds of clovers, including *Trifolium pratense, T. incarnatum, T. hybridum,* and *T. repens* are eaten, as well as alfalfa and sweet clover (*Melilotus alba*). Webster reported white clover being eaten in preference to red in Ohio, but other observers, including the present writers, have noted that red clover and alfalfa are more often chosen. Both larvæ and adults will feed on beans, and the adults have been observed eating timothy, burdock, soy bean, and the flowers of goldenrod. W. H. Larrimer observed beetles feeding on corn foliage at McFarland, Kans., August 10, 1915.

> In Europe this species has several times been reported as injurious locally, but only for short periods. The earliest record I have found is Villa's statement at the time of the outbreak in the region of Lombardy in 1868 when he says that Moretti in a revised edition of Gene's publication in 1853 reports this species as injuring clover and believes that this referred to a previous serious injury about 1834–35. * * * In 1868 the species caused serious damage in Northern Italy so that a commission was appointed to investigate the matter and published several papers giving recommendations. Targione-Tozzetti in 1879 notes a severe outbreak in the region around Florence. It was again injurious in the region of Florence in 1902–3. (Titus 7, *p. 408.*)

The first record of the destructive work of this species in America occurred at Barrington, Yates County, N. Y., in 1881 and 1882, but since that time it has been controlled largely by an epidemic fungous disease. The clover-leaf weevil has spread rapidly over the country, and outbreaks have occurred repeatedly, but usually have been checked before serious damage was done. The most notable of these late outbreaks occurred in Michigan and persisted for a year or two before the fungus succeeded in checking the insect. In this connection Pettit (*5, p. 46*) records that cattle pastured on clover at the time the larvæ were being destroyed by this fungous disease were made seriously ill, and so many complaints were received in Michigan that it was advised that cattle be kept out of clover pastures until the bodies of the dead larvæ had dropped to the ground.

LIFE HISTORY.

LIFE CYCLE.

The life history of this species was first studied in the United States by Riley (*6, p. 171–179*) in 1882, and Folsom's paper on clover insects in 1909 (*3, p. 155–164*) gives much additional information. Numerous other writers have added notes on the distribution, habits, and life history, and these have been drawn on by the authors. The life cycle is one year according to observations made by the present writers, which agrees with the results obtained by Folsom. Briefly, the life cycle is as follows:

The eggs are laid in or on different parts of the clover or alfalfa plant, more often in a puncture on the stem or leaf sheath or on the outside of these parts in the fall of the year between September 8 and November 29. The eggs laid previous to October 25 hatch the same fall, and hibernate as first, second, and third instar larvæ while those laid after October 25 usually remain over winter as eggs, and, except in the case of eggs laid quite late, hatch the following March. The larvæ feed on the foliage of their hosts and become full grown by the last of May, when they spin cocoons at or just below the surface of the soil, pupating therein and issuing as adult beetles in June or July. The beetles feed on foliage of clover intermittently until September when they mate, and soon thereafter egg laying begins.

Since the period of oviposition extends over a number of weeks and, furthermore, eggs laid late in the season do not hatch until spring, the various stages greatly overlap. The accompanying diagram (fig. 7) illustrates graphically the life cycle of *Hypera punctata.*

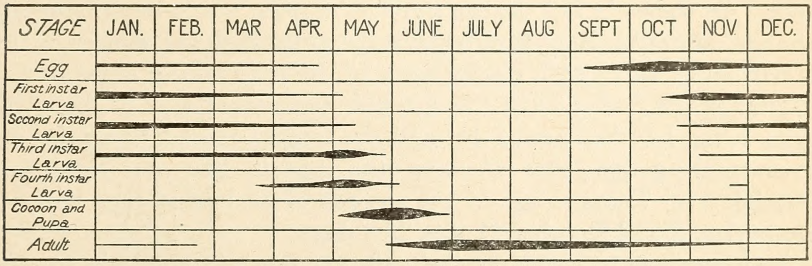

FIG. 7.—Diagram illustrating life history of the clover-leaf weevil and indicating the abundance of the different stages during the season in the latitude of La Fayette, Ind.

The experiments made by the authors were not started until September 8, 1915, but some of the beetles collected September 1 had oviposited previous to September 8.

The eggs are laid in the fall during September, October, and the first two weeks in November, although oviposition was observed as late as November 29 in 1915. Females laid during periods of 64 to 68 days and individuals laid the following numbers of eggs: 74, 83, 108, 162, 166, 176, 181, 196, 287. Following the last oviposition the females lived from 1 to 16 days, and all the males and females used in the experiments in the fall of 1915 and kept out of doors under normal conditions were dead by February 18, 1916.

The beetles laid consistently between September 8 and November 15, there being a marked increase in the numbers laid between October 15 and November 15. After November 15 the laying records were scattered. It was noticeable that none of the eggs laid after October 21 hatched previous to March 1, 1916, except in one case when eggs laid October 25 hatched during a period of mild weather between December 20, 1915, and February 18, 1916. Since eggs laid after November 13, in 1915, failed to hatch the following spring, it appears that partial development of the embryo previous to cold weather is necessary to enable the egg to survive the winter. Approximately 30 per cent of the eggs overwintering in vials hatched, but it is probable that this is below the normal under natural conditions.

The eggs, which are a watery yellow when laid, soon grow darker yellow and early in the fall turn dark in from 2 to 6 days. The last laid eggs may retain their yellow color through the winter, all development being arrested. Early in the fall the eggs that have darkened become sculptured in a day or two, but later on the time elapsing between these changes may be lengthened to weeks or months. The next noticeable change in the egg is the rapid pigmentation of the head of the embryo which appears beneath the shell as a distinct round black spot. In the early fall the egg hatches in from 1 to 3 days after this change, although later such eggs may go through the winter in this condition or may hatch during some of the mild winter days.

During the fall of 1915 the shortest egg period was 13 days, the eggs being laid September 10, and the longest period, excepting for overwintering eggs, was 46 days, the eggs in this case being laid October 21. The average of the records of 50 lots of eggs between September 8 and October 21 was 25.8 days.

Just previous to hatching the embryos are active within the egg and can be seen moving around. They emerge by cutting a small round hole large enough for the larva to pass through, usually near one end of the egg. The eggshells are never eaten by the larvæ after they have emerged. The larvæ will commence feeding at once if placed on clover leaves, but may live a long time without food, as in the case of those hatching during the winter. The length of the larval stages is very variable in the fall, for feeding is suspended during adverse weather and resumed in mild. The shortest time secured for the first stage was 13 to 14 days, for the second stage 12 to 14 days, and for the third stage 10 days. No fourth-stage larvæ were obtained in these experiments during the fall as the cold weather sent the larvæ into hibernation. Table II summarizes the lengths of the different stages and larval instars as observed at La Fayette, Ind., in the spring and early summer.

Numerous larvæ were collected on different dates during the winter to determine the ages of the wintering larvæ and the results of such collections are given in tabular form in Table III. No adults were found by the authors but Folsom (*3*) records that hibernating adults collected in the spring were much enfeebled and unable to lay eggs. He suggests the possibility of a second generation of beetles farther south which hibernate and oviposit in the spring, and observations made by different members of the Bureau of Entomology would indicate that ovipositing beetles in the latitude south of southern Indiana are capable of laying fertile eggs in the spring and that two broods sometimes, if nor ordinarily, occur annually.

The larvæ have often been observed feeding during the mild days of winter on the small leaves at the crown of the clover plant. In the early spring the larvæ commence to feed as soon as the clover starts its growth, but feeding and growth are intermittent, due to climatic changes, so that larvæ of all stages may be found during April and May. Larvæ in the first three instars are most numerous in April, but beginning with May there is a gradual falling off in numbers of larvæ in the first two instars, those in the third and fourth predominating. By the end of May few active larvæ remain and by June 20 practically all have completed their growth and spun their pupal cocoon. Tables II and III give the number of days passed in different stages and the dates of their occurrence in the field.

TABLE II.—*Hypera punctata: Length of larval and pupal periods.*

Stage.		Number of examples.	Minimum.	Maximum.	Average.
			Days.	*Days.*	*Days.*
Larva	First instar	6	17	20	$18\frac{2}{3}$
	Second instar	19	4	15	10
	Third instar	23	4	13	$8\frac{1}{2}$
	Fourth instar	32	8	21	$14\frac{1}{8}$
	Spinning cocoon	57	1	2	1+
	Prepupa	44	1	10	4
Pupa		53	5	16	$11\frac{1}{10}$
Length of time remaining in cocoon after adult		56	1	5	$2\frac{1}{8}$

TABLE III.—*Hypera punctata: Stages occurring in field at different dates.*

Date collected.	First stage.	Second stage.	Third stage.	Fourth stage.	Prepupa.	Pupa.
1915.						
Oct. 14	2	......	......	......	......	......
Oct. 19	2	3	......	......	......	......
Oct. 20	1	......	......	......	......	......
Oct. 21	1	3	......	......	......	......
Oct. 22	1	1	......	......	......	......
Oct. 27	18	2	......	......	......	......
Nov. 4	19	19	2	1	......	......
Nov. 23	18	45	14	1	......	......
Dec. 13	32	34	13	......	......	......
1916.						
Jan. 3	6	7	1	......	......	......
Jan. 28	33	28	5	......	......	......
Mar. 25	......	3	4	1	......	......
Mar. 31	1	6	4	......	......	......
Apr. 3	......	6	4	1	......	......
Apr. 5	2	4	2	2	......	......
Apr. 10	......	3	2	......	......	......
Apr. 15	10	15	12	4	......	......
Apr. 18	......	4	1	......	......	......
Apr. 20	3	2	1	......	......	......
Apr. 27	2	5	9	6	......	......
May 5	2	11	14	14	......	......
May 8	......	......	9	9	3	......
May 18	......	......	10	10	1	......
May 25	......	......	......	2	1	1
May 26	......	......	......	4	......	......

The cocoon (fig. 6) is spun in an oval cell made by the larva in the soil just beneath the surface or among the stems and rubbish at the base of the clover plant. This cell is formed by the larva turning around and around with its body in the characteristic curved position and is smoothed with its head. The spinning is done by the mouth but the bulk of the spinning material is drawn from the anus and every few minutes during the construction of the cocoon the larva reaches back to the anus for a fresh supply. Knab (*4*) shows by his dissections of these larvæ that there is an enormous development of the malpighian tubes and reasonably supposes that the bulk of the spinning material primarily arises in these tubes and is drawn from the anus by the larva. He further observes that the necessarily smaller amount of silk produced by the silk glands which open into the mouth may be used in waterproofing the other materials, for he has noticed the larva passing its mouth along the threads after they have been drawn out and put in place.

The cocoon is spun in from 1 to 2 days and the larva pupates within four days after the cocoon is completed. In one instance at La Fayette, during excessively hot weather, a larva pupated within a day after completing the cocoon, and in another instance under adverse conditions this prepupal period extended over 10 days. The newly formed pupa is pale green but later changes to yellow and finally to a brownish color.

The beetle issues 5 to 16 days after pupation, the average pupal period, according to our observations, being 11 days. The adult is at first soft and pale green, the wings protruding beyond the elytra, the pupal and larval skins remaining as a small shriveled pellet at an end of the cocoon. The elytra gradually become silver, iridescent, and pale green through which the maculations are faintly visible, the ventral surface of the abdomen is pale green, the lower part of the head reddish brown, the prothorax tan colored. The wings are soon withdrawn beneath the elytra and within 24 hours the insect has become mature, after which the beetle issues by eating an irregular hole in the cocoon. The first beetles issuing at La Fayette in 1916 emerged on May 26 and the last June 26, although other observers in the same latitude give the period of greatest emergence as the last week in June, the period of emergence extending from May 9 to July 15.

After emergence the beetles feed during the night and conceal themselves during the day under rubbish or in cracks in the ground. They feed steadily for about two weeks, after which they become semidormant and remain inactive until about the first of September, whereupon they become sexually active.

COPULATION.

As stated, the beetles resume activity the last of August or the first of September. The record of copulation for one pair reads September 15, October 4, 8, 14, 17, 27, and November 7, the female of this pair laying 196 eggs between September 25 and November 27. As these beetles were examined but once or twice each day probably only a few of the copulations were observed. Mating probably takes place normally during the day, for beetles in copula have been collected in the field only at this time.

OVIPOSITION.

The records of other writers give as places of oviposition the ground, base of plant, stems, and the inside of dead stems. Careful search was made in the field for eggs during the laying season, but only three were found, these being placed singly on dead stems. In the breeding cages the beetles rarely laid on the ground but in or on some portion of the plant. When fed alfalfa they laid the eggs singly in punctures in the stem. (Fig. 3.) Sometimes it seemed impossible for the beetle to make punctures enough to contain all the eggs she wished to lay, so she would fasten several in a mass on the stem by means of a rapidly drying secretion. When fed clover the females practically always laid inside the petiole or the leaf sheath; and if these were not present and only stems provided, the eggs were laid as in alfalfa. In laying the eggs in the petioles the female usually cut a hole with her mandibles just large enough to admit one egg at a time, through the side of the petiole, but in the case of an old matured petiole a cavity would be made into which the ovipositor could be thrust and from 1 to 23 eggs laid, part of which would be pushed up and part down the stem. Measurements showed that the eggs were sometimes pushed in the petiole as far as 3⅓ mm. above and 6 mm. below the puncture. Unless the last egg was left in the opening, as infrequently occurred, the opening practically healed before the eggs hatched. In case the petiole was solid, the inside would be eaten out and the eggs laid as before. It was noticeable that petioles and their leaves never appeared to be injured when eggs were laid in them. The eggs were also readily laid in the sheath at the base of the petiole, a tiny hole being cut through its side and a mass of eggs deposited within, as many as 33 eggs being laid by one female at one time in this way. In all the experiments the largest number of eggs laid by one female at one time was 34, 18 to 25 being common. The eggs are usually laid at night but some were recorded between 8 and 9 a. m., and it was noticeable that there was a marked tendency to lay during the day in the fall when the nights were very cold.

HABITS.

The young larvæ feed during the day, largely on the underside of the leaves, eating small holes in them. Whether they feed from the underside because it is more protected or because there are more epidermal hairs for them to cling to is not known. After the third molt they eat patches from the edges of the leaves, feeding only at night, and dropping to the ground when disturbed, curling themselves tightly end to end. During the day they lie coiled at the base of the plant, hiding under dead leaves and other débris.

The larvæ are legless but are supplied with pairs of muscular fleshy tubercles on the ventrum of the segments and these are used in grasping epidermal hairs, edges of leaves, etc. The young larvæ move about by grasping the epidermal hairs with their mouths, the folds between segments, and the transverse folds. Older larvæ ascend petioles spirally, using the muscular abdomen as a means of locomotion, and with each successive advance securing a new hold with the mouth and forepart of the body. As this is repeated, the larvæ move around and around the stem with a spiral motion.

When handled, the larvæ will often emit a greenish saliva, which appears to be for defensive purposes, and in addition may pass their blackish semiliquid waste.

The young larva molts by first coiling itself about a bunch of epidermal hairs and then crawling out of the larval skin, which opens in the head region, leaving the empty skin coiled around the hairs. The larvæ have never been observed to eat the cast skins.

The adult, after casting off the pupal skin, which shrivels to a small pellet at one end of the cocoon with the last larval skin, soon eats its way out and feeds during the summer, ragging the clover leaves and sometimes eating the plants to the ground. During the day they usually hide under rubbish or in cracks in the ground but have been observed to feed, and many have been collected by sweeping the tops of clover plants at this time.

FEEDING EXPERIMENTS.

Feeding experiments were conducted at La Fayette, Ind., to determine the amounts of clover foliage eaten by *Hypera punctata* at different seasons and during the larval and adult stages (Table IV). The amount of food eaten by individual larvæ averages 3.09 square inches of red clover foliage from 25 examples studied, and of this amount 2.48 square inches, or approximately 80 per cent, is consumed during the last instar. Comparatively small amounts of leaf tissue are eaten during the first three instars—0.019 square inch being eaten during the first, 0.087 in the second, and 0.504 in the third instar (Table V and fig. 8).

As has already been noted, the beetles begin to feed immediately upon issuing in May and June and continue for a period of about two weeks. They then become dormant and do not resume feeding until early in September, coincident with the beginning of sexual activity. During the early period of feeding the foliage is the principal part of the clover plant eaten, but in late fall the beetles, and especially the females, show an increasing tendency to feed upon the stems and petioles.

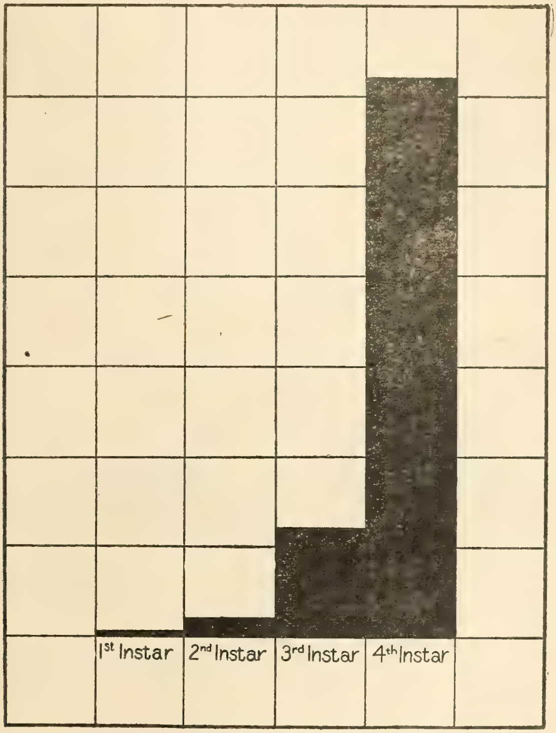

FIG. 8.—Diagram showing average comparative amounts of clover foliage consumed by larvæ of the clover-leaf weevil in their different instars.

The life of the adult, therefore, is divided into two distinct feeding periods, separated by one of inactivity during the months of July and August. During the first active feeding period enough nourishment is taken to tide the insect over midsummer when but little food is available. Beetles deprived of foliage immediately after emergence from the cocoon die within a few days. According to experiments made by the writers, the average amount of clover foliage eaten by individual beetles prior to the inactive summer period, during what might appropriately be termed the predormant period, is 3.28 square inches, which is consumed in an average of 23.5 days. Beetles issuing late in May become dormant late in June, while those emerging from the middle to the end of June do not stop feeding until early in July. The amount of foliage eaten during the postdormant period, that is, after the summer inactive period, is 1.48 square inches and extends over an average of 82 days, that is, not one-tenth as much per day as is eaten in the predormant stage (Table VI and fig. 9).

The amount of food consumed by the individual beetle during its entire adult stage averages 4.76 square inches, 0.045 of an inch per day during the feeding periods. The feeding by the beetles is therefore so slow and gradual that they seldom do an appreciable amount of injury except when in unusual numbers. On the other hand, the larva needs approximately 2 square inches less of foliage for its development than is eaten by the adult, but of the 3.09 square inches of leaf eaten by each larva, 2.48 inches are consumed during the last instar, which occupies a period of 10 days or less, and the large amount of foliage taken in so short a period greatly increases the liability of injury.

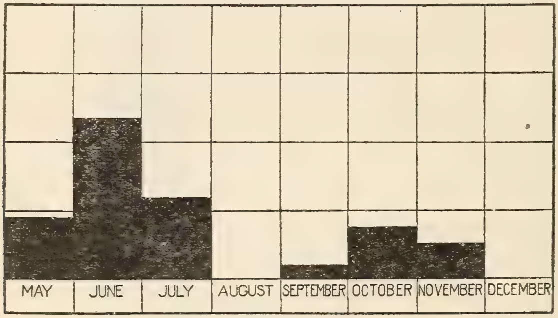

FIG. 9.—Diagram showing the comparative amounts of clover foliage eaten by adult beetles of the clover-leaf weevil during the different months of the season.[1]

Tables IV, V, and VI give the amounts of clover foliage eaten by adults and larvæ.

TABLE IV.—*Average amounts of clover foliage eaten by adult and larva of Hypera punctata.*

Stage.	Average amount food eaten.	Average length feeding period.	Average per day.
	Inches.	*Days.*	
Predormant beetle	3.28	23.5	0.139
Postdormant beetle	[1] .74	82.0	.009
Larva 1st instar	.019	18.6	.001
Larva 2d instar	.084	10.0	.008
Larva 3d instar	.504	8.5	.059
Larva 4th instar	2.480	14.0	.177
Total—larva	3.087	51.1	.06
Total—beetle	4.02	105.5	.038

[1] The beetle consumes at least an equal amount of stem during this period and this could not be measured.

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[1] As recorded in Table IV, at least an equal amount of stem is eaten in the fall in addition to the foliage, and due consideration is taken of this fact.

TABLE V.—*Amount (inches) of clover foliage eaten by larvæ of Hypera punctata.*

Cage No.	First instar.	Second instar.	Third instar.	Fourth instar.	Total.
Laf. D454:					
ba	0.0025	0.08	0.66	2.14	3.1425
bb	.005	.1	.2525	2.4121	2.7696
bc	.005	.055	.195	2.415	2.67
bd	.0025	.005	.62436	2.80952	3.4414
bf	.0025	.03	.37		
bg	.015	.06	1.23868	2.668	3.9817
bh	.01	.11	.54	2.90332	3.5633
bi	.0275	.08	.2975	2.61	3.015
bk	.005	.05	.80428	2.27668	3.29
bl	.03				
bm	.005				
bn		.1025	.38375	2.70375	
bo	.025	.1025			
bq	.03	.18			
br	.025	.12	.47748	2.85104	3.4735
bs	.03	.396	1.0034	1.11412	2.5435
bt	.02	.035			
bu	.04	.09	.77892	3.05864	3.96756
bv	.01	.055	.905	1.945	2.915
bw	.0125	.025			
bx	.04	.1	.5125	2.7475	3.395
baa		.025	.7825	1.8175	
bab	.0125	.1925	.763		
bac	.0275	.04	.7725		
bad	.025	.035	.495	2.4325	2.98
baf	.0325				
bag	.065	.1	.4428	1.94452	2.5524
bah		.0375	.2825	1.465	
bai	.025				
baj	.0225	.025			
bak	.0125				
bal	.03				
bam	.01				
ban	.0075				
bao	.01				
bap	.014	.035	.3475	1.6125	2.009
baq	.03	.04844	.56052	2.40124	3.0401
bar	.045	.07612	.3806	2.23516	2.7369
bas	.01	.0525	.07275	1.9425	2.0778
bat	.02	.1			
bau	.0175	.055	.5875	2.2475	2.9075
bav	.008	.04	.465	3.205	3.718
baw	.01	.145	.3125		
bay	.01	.03			
baz	.02	.05536	.63664	2.66892	3.3809
ca	.02	.08304	.346	2.87872	3.3277
cb	.01	.1221	.3375	1.845	2.3146
cj	.02	.025			
ck	.0025	.0675	.51	2.11	2.69
cl	.0325	.0375			
cm		.0775	.225		
cn		.0625	.825	2.7025	
cp			.4675	3.0625	
cq		.02	.22		
cr		.08	.68508	3.3908	
cs		.0525	.66	3.7925	
ct		.242			
cu		.0375	.3875	3.4425	
cam			.455		
Average	.019	.0874	.50401	2.48035	3.09076

TABLE VI.—*Amounts (inches) of clover foliage eaten by beetles of Hypera punctata.*

DURING PREDORMANT PERIOD.

Cage No.	Number of beetles per cage.	Date of emergence.	Date stopped feeding.	Total feeding period.	Amount of foliage eaten during—				Sex.
					May.	June.	July.	Total.	
				Days.					
D363a	1	May 25	June 20	26	1.36	1.08	....	2.44	♂
D363b	1	May 26	June 14	19	1.19	2.46	....	3.65	♂
D363g	1	May 28	June 20	23	.25	3.13	....	3.38	♂
D363n	1	June 3	June 27	24	....	4.9	....	4.9	♀
D363s	1	June 4	June 30	26	....	5.61	....	5.61	♀
D363t	1	...do...	...do..	26	....	4.39	....	4.39	♀
D363aa	1	June 13	July 5	23	....	3.07	0.93	4.00	♀
D363ad	1	June 15	July 8	24	....	3.56	.84	4.4	♀
D363ag	1	June 17	July 7	21	....	2.51	.52	3.03	♀
D568a	2	June 27	July 10	24	....	1.06	2.19	3.25	♂ ♀
D568c	2	...do....	July 8	22	....	2.39	2.6	4.99	♂ ♀
D568d	2	...do....	July 10	24	....	1.46	3 73	5.19	♂ ♀
Total average per beetle	....	....	....	23.5	.93	2.37	1.2	3.28	

DURING REPRODUCTIVE PERIOD.

Cage No.	Number of beetles per cage.	Amount of foliage eaten during—				Total period.	Sex.
		September.	October.	November.	December.		
D363a	2	0.152	0.792	0.498	0.149	1.591	♂ ♀
D363b	3	....	.754	.228	.032	1.014	♂ ♀ ♀
D363g	2	.104	1.240	.430	.232	2.006	♂ ♀
D363n	2	.080	.922	.283	.155	1.440	♂ ♀
D363s	2	.045	.640	.459	.346	1.490	♂ ♀
D363t	2	.436	.818	.440	.280	1.974	♂ ♀
D363aa	2	.249	.461	.503	.195	1.408	♂ ♀
D363ad	2	.285	1.221	....	....	1.506	♂ ♀
D363ag	2	....	.806	.505	.138	1.449	♂ ♀
D454e	2	....	.844	1.341	.690	2.875	♂ ♀
D454h	3	....	.376	.563	.136	1.075	♂ ♀ ♀
Total average per beetle	....	.0965	.369	.239	.011	.7155	

NATURAL ENEMIES.

The most important check on the abundance of *Hypera punctata* is the fungous disease *Empusa sphaerosperma* Fres., which kills the larvæ in vast numbers during the months of April and May and again in October and November. This disease is epidemic, and contagion so rapid and thorough that in from two to four weeks it is almost impossible to find living individuals where previously there were thousands.

> The sick larvæ of all ages crawl up the herbage during the night, and instead of again concealing themselves near the ground on the approach of light, as the healthy ones do, ascend as high as possible, and if on grass, coil themselves in a horizontal position about the apex of the blade, or if on other objects, take a position as nearly similar as the shape of the object permits. If disturbed before the middle of the forenoon the majority are still able to crawl, although sluggishly; by noon most of them are quite dead, but unchanged in appearance. . . . Late in the afternoon, the body has changed from the normal yellowish or pea green and smooth appearance to velvety gray. The next morning there is only a small, blackened and shriveled mass remaining, while the surrounding foliage is powdered with a whitish, clinging dust, composed of the spores of the fungus. (J. C. Arthur (*1, p. 285–289*).)

The fungus mycelia ramify through the body of the larva, absorb the body fluids, but do not penetrate the tracheal or alimentary tract. A portion of the mycelium pushes out through the ventral side of the larva and forms rhizoids attaching the larva securely to its support. Other mycelial threads push out from other portions of the body and form a gray velvety coating over the body of the larva. On the tip of some of these branches is formed a spore which is projected forcibly into the air to infect other larvæ with which it may come in contact. These are the temporary spores and germinate at once to infect new hosts. Resting spores are also formed and these develop in the body of the larva and are capable of retaining their virility for a longer time.

This disease is well distributed in the United States and attacks numerous other insects, among them the common cabbage worm (*Pontia rapae* L.), mosquitos, flies, ichneumon wasps, and certain leafhoppers.

According to Riley the larva of a small beetle (*Collops quadrimaculatus* Fab.) feeds on the eggs of the clover-leaf weevil and one of the tiger-beetles (*Cicindela repanda* Dej.) probably preys on the larvæ. In Europe several larval parasites are known but none have been recorded from this country. H. L. Parker, of the Bureau of Entomology, collected a clover-leaf weevil larva at Hagerstown, Md., April 30, 1915, bearing a tachinid egg, but the adult was not reared therefrom.

Poultry, especially turkeys and chickens, are fond of the larvæ and beetles, and if given the opportunity will consume large numbers.

Birds are valuable and important natural checks on this insect and according to the Bureau of Biological Survey (*2, p. 7*),

> The common or large clover-leaf weevil is the prey of 25 species of birds. The nighthawk, crow, red-headed woodpecker, purple martin, and crow blackbird have the best records for the destruction of adults, and the Savannah and vesper sparrows of the larvæ.

In literature we find the following birds listed as feeding on *Hypera punctata:*

American crow	*Corvus brachyrhynchos.*
Bobolink	*Dolichonyx oryzivorus.*
Bobwhite	*Colinus virginianus.*
Catbird	*Dumetella carolinensis.*
Crow blackbird	*Quiscalus quiscula.*
Flicker	*Colaptes auratus.*
Horned lark	*Otocoris alpestris flava.*
Kingbird	*Tyrannus tyrannus.*
Meadowlark	*Sturnella magna.*
Nighthawk	*Chordeiles virginianus.*
Purple martin	*Progne subis.*
Red-headed woodpecker	*Melanerpes erythrocephalus.*
Robin	*Planesticus migratorius.*
Sparrows:	
English	*Passer domesticus.*
Savannah	*Passerculus sandwichensis savanna.*
Vesper	*Poœcetes gramineus.*
Wood pewee	*Contopus virens.*

Toads and frogs sometimes prey upon the weevils. Mr. T. S. Wilson, of the Bureau of Entomology, found one adult in a toad's stomach at Wellington, Kans., July 12, 1915, and Mr. H. L. Parker found 11 adults and one pupa of *Hypera punctata* in the stomachs of four frogs (*Rana* sp.) collected at Bridgeport, N. Y., December 6, 1915, out of 14 examined.

CONTROL.

The outbreaks of this insect are eventually suppressed by the fungous disease mentioned and, except in rare cases, before serious damage is done. Often what promises to be a serious attack is wiped out by the disease just as it seems to appear most threatening, or, as was the case in 1917, the weather conditions may enable the clover to make a rank growth and overcome injury by the larvæ, even though they may be present in enormous numbers.

Usually the need of remedial precautions does not become apparent until too late to apply practical measures. The insect does not ordinarily become abundant in a clover field until the second season, and in localities where it is known to occur in occasional or frequent abundance it is a good practice to pasture lightly all first-year clover in the fall or to clip it back in spring and further to hinder the increase of this insect in the locality by thoroughly plowing under the second year crop in the fall.

Other measures, such as burning clover fields in winter, rolling, dragging, and flooding, have been advised, but the practical value of these measures has not been proved; and clipping and plowing under clover at the end of the second season, in themselves valuable in the control of other clover insects as well as being good farm practices, seem all that is necessary, as a rule, for prevention of injury

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